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AUTHOR Olson, Janet S.
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ABSTRACT

The relative effectiveness of verbal and visual augmentation of rate-modified speech in the presentation of technical material was investigated. Subjects were 40 graduate students who used instructional materials consisting of normal and compressed audiotape versions of the Dwyer heart script, printed copies of the script, and black and white simple line drawings. Treatments were either normal version/no augmentation, compressed version/no augmentation, compressed version/text augmentation, or compressed version/visual augmentation. Posttests measured achievement in spatial restructuring, recall of specific information, spatial analysis, and interrelationships of information. Findings indicate that compressed messages do not differ in instructional effectiveness from normal rate messages for presenting technical information. However, compressed and normal speed materials are not equally effective in facilitating student achievement of different instructional objectives. The rate of presentation that is most effective in presenting information is dependent upon the type of learning task, and the effectiveness of text or visual augmentation to a compressed passage is dependent upon the required instructional task. A 19-item bibliography is included. (Author/LMM)

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A STUDY OF THE RELATIVE EFFECTIVENESS OF VERBAL AND VISUAL AUGMENTATION OF RATE-MODIFIED SPEECH IN THE PRESENTATION OF TECHNICAL MATERIAL

Janet S. Olson
Speech and Language Clinician
Allegheny Intermediate Unit
Pittsburgh, PA 15219

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Research and Theory Division
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ABSTRACT

The purpose of this study was to investigate the relative effectiveness of verbal and visual augmentation of rate-modified speech in the presentation of technical material. Research has shown that the complexity of the stimulus material has a direct effect on achievement (or comprehension) at compressed rates. It may be possible to supplement the compressed rates of speed so that results approaching or surpassing normal rates can be achieved. The addition of text or visuals to accompany an aural presentation may provide the additional information necessary to allow the faster compression rates to be as effective as a normal rate. Research also suggests that focus should be directed to the specific learning task being presented. This implies that specific learning tasks, presented via auditory channels, be evaluated using instruments designed to measure achievement of each of those specific tasks. The population consisted of 40 graduate students. Materials used consisted of normal and compressed versions of the Dwyer Heart script, printed copies of the script, black and white simple line drawings and the related evaluation instruments. Subjects were assigned to one of four treatment groups: normal version/no augmentation, compressed version/no augmentation, compressed version/text augmentation, compressed version/visual augmentation. After listening to their respective treatments, students were administered the four achievement tests. Analysis of variance procedures were applied to the data.

Purpose

The purpose of this study was to investigate the relative instructional effectiveness of rate-modified speech used alone and when augmented with either visual or verbal materials in the learning of technical material. Considerable research has investigated the comprehension of verbal materials presented by means of compressed or rate-modified speech (Duker, 1974). A comprehensive review of this research (Olson and Berry, 1982) indicated, however, that limited research has focused on the use of rate-modified speech with technical materials and the effect of verbal and visual augmentation upon comprehension of compressed audio messages. Additional research would provide: (1) information concerning the use of rate-modified speech with material that is technical in nature, (2) a determination of how specific learning tasks are affected by using rate-modified speech, and (3) an explanation of the relative effectiveness of verbal and visual augmentation to rate-modified messages.

Rate-Modified Speech

For many years the rapid learning of large amounts of information has been a continuing educational concern. In more recent years this persistence has intensified. Duker (1974) identified the problem that large amounts of information impose upon the learner. He noted that today's society has become more dependent upon communication, necessitating the listener to accommodate a mass of knowledge that is growing in geometric proportions. The proliferation of journals, newspapers, books and other types of media has evolved to a point where an individual can no longer remain current at the same pace with which new developments occur. The problem that Duker identified 10 years ago is even more apparent today. With the new technologies

that the microprocessor affords comes an era where the learner is inundated with material to read or merely peruse at a pace that becomes more rapid every day. The technology that permits society's advancements and developments has also contributed to a knowledge base that has become so enormously unwieldy that the learner cannot keep pace.

This imperative is compounded by the fact that individuals learn at different rates. Since time spent in instruction is an important factor in maximizing instructional efficiency, it is of vital importance to identify a means by which the learner can be aided in increasing the effectiveness of the time spent in learning.

Today's technology has contributed to the current state of affairs concerning the information explosion that plagues the learner. Current technology, however, also offers a number of viable solutions within its own parameters. One means this new technology has provided is that of altering recorded speech so that the instructor or student may adjust the rate of presentation to suit his needs. This technique is termed rate-modified speech or more popularly referred to as "compressed speech" (Silverstone, 1974).

Silverstone described this method of rate modification as the "...reproduction of an original recording in which the word-per-minute ratio is changed to a slower or faster rate of speech without eliminating the pitch or natural quality of the voice."

Considerable research has focused on rate-modified speech and its use in increasing learning efficiency through the auditory mode. These investigations have contributed to an enormous body of knowledge that spans over five decades (Duker, 1974; Olson and Berry, 1982; Orr, 1968). Generally, compressed speech has been shown to be as efficient as normal

rates of speech. The average conversational rate at which a person speaks is in the range of 100 to 150 words per minute (Nichols and Stevens, 1957; Silverstone, 1974). A listener can comprehend and process information at a rate up to or approximating 400 words per minute (Silverstone, 1974). This creates a speaking/listening discrepancy since a listener can comprehend spoken material up to four times faster than the speaker can send the message. The result is a listener who becomes bored or whose attention begins to wander.

Substantial research has focused on both intelligibility and comprehension of rate-modified speech. Intelligibility refers to the extent that one is able to repeat information which was presented or to discriminate what one has heard. Comprehension refers to the ability to extract knowledge or information from what one has heard, usually by completing an objective test. Generally, no significant differences have been found between normal and compressed modes in terms of comprehension or intelligibility at rates up to 250 words-per-minute (Foulke, 1966, 1967). Foulke (1971) suggested that this implies working, auditory processing limit of approximately 275 words-per-minute.

Foulke (1968a) reported that, with word rates ranging from 125 to 400 words per minute, comprehension was found to be adequate until the word rate exceeded 250 words-per-minute. As the word rate rose higher, the level of comprehension decreases in an inverse proportion. Foulke hypothesized that adequate processing time is needed for perception of words in order for comprehension to occur. If processing time is reduced, a decrease in comprehension results. Lost processing time was indicated to be a contributing factor in the level of comprehension. Hausfeld (1981) presented strong evidence for a working memory processing limit of approx-

imately 275 words-per-minute.

Foulke (1968b) indicated that in measuring comprehension, there are two groups of factors which must be taken into consideration: (1) organismic features, and (2) characteristics of the signal. Organismic factors include age, sex, intelligence and previous experience with the subject. Characteristics of the signal are concerned with word rate, method of compression and rate of occurrence of the speech sounds.

Relatively few researchers have devoted adequate attention to the characteristics of the message itself. This third area for consideration includes readability, complexity of information and the relative density of ideas or concepts.

Substantial research has focused on both intelligibility and comprehension of time-compressed speech. Generally no significant differences have been found between normal and compressed modes in terms of comprehension or intelligibility at rates up to 250 words-per-minute (Foulke, 1966, 1967).

Research has been less conclusive, however, in determining the effectiveness of utilizing compressed materials when the content is of a more complex or technical nature. The earlier research in rate-modified speech has generally concluded that faster rates were equal to or more effective than slower rates. Subsequent research, however, raised the issue of using material that was of a more complex, technical nature, and challenged the former conclusion that faster rates were superior.

One methodological problem inherent in much of this research work is that they used a variety of recorded messages which did not take into account the specific learning objectives or tasks and the complexity of information. The efficiency index of Fairbanks used in past studies assumed that all passages used were of equal difficulty and importance.

Factors such as the length of the stimulus materials, density of ideas, items learned and not learned, and the difficulty of items learned and not learned, were not considered (Adelson, 1975). Other research suggests that regardless of the speaking rate utilized, increasing the difficulty of the stimulus material results in a reduction of the amount of material that is comprehended (Spicker, 1963). Grammatical complexity has also been shown to have an inverse effect on the amount of comprehension of compressed material (Reid, 1968). The type of information used has an effect on comprehension and may also represent related but different aspects of listening comprehension.

It has been established that material containing different types of information such as drawing inferences, formulating ideas and dealing with facts yields different results in comprehension of compressed materials (Rossiter, 1971). These finds seem to indicate that material that is more complex or technical in its content would be more adversely affected by higher rates of compression.

There exists from these research efforts substantial evidence that rate-modified speech is a valuable learning tool. The effectiveness of this learning tool, however, may be affected by the addition of certain supplemental information in an effort to provide additional or redundant information via another channel. Since it has been established that rate-modified speech has a positive effect on comprehension of compressed materials, it is conceivable that the addition of text or visual augmentation would further increase this effect.

The use of text and visual materials to augment rate-modified messages has been explored in past research. Generally, their use with materials of varying compression rates has been found to be of significant educational

importance. The redundant information provided by the printed text and the additional cues provided by visuals has aided in the processing of the compressed material. It is of interest to determine if these two types of augmentation (text and visuals) provide additional support to compressed material that is of a technical nature. The additional of visual augmentation to accompany an aural presentation may provide the additional information necessary to allow the faster compression rates to be as effective as a normal rate. The use of printed text may provide the redundancy needed to comprehend the spoken material. Similarly, the use of illustrations may provide enough additional information for the learner to organize or restructure the material.

It would appear that the visual augmentation of compressed auditory material may improve comprehension. If such a difference does occur, it is necessary to identify which type of visual augmentation, if any, is more effective in providing for this difference. No research to date has investigated this aspect of comprehension of rate-modified speech.

In consideration of the complexity and difficulty of materials there is also at issue the type of learning task that is involved. Different types of listening learning tasks as those identified by Rossiter (1971) yielded differing results in terms of comprehending rate-modified passages. Further exploration of different learning tasks and objectively measuring their completion may help to determine what specific tasks may be more suited for information that is modified in rate of presentation.

In order to measure the effectiveness of rate-modified speech, it is of major concern to establish a means of standardizing the degree of complexity of stimulus passages and the use of augmentation with the stimulus passages for testing and evaluation purposes. This standardization

is imperative for determining results from an experiment and for generalizing to other research efforts relative to this area of investigation.

Orr (1971) identified the problem that exists due to a lack of standardization of testing instruments to measure variables relative to rate-modified speech. Since no one method or procedure for evaluating rate-modified materials is recognized, generalizations from one study to another remain difficult to make and are frequently of questionable validity.

Until the present, no standardized instruments have been developed, and those which had been developed represented a global measure of a variety of learning tasks. Work done by Rhetts (1974) suggests that learning research should also focus on the specific learning task being presented. Such a charge would imply that specific learning tasks, presented via auditory channels, be evaluated using instruments designed to measure achievement of each of those specific tasks. For this reason, a part of the research and evaluation materials developed by Dwyer (1967) was employed in this investigation. The evaluation instruments incorporated into this package allow the researcher to evaluate learner achievement relative to four different learning tasks or objectives: drawing or spatially restructuring information, terminology or recall of specific information, identification or spatial analysis and comprehension* or interrelating information. In addition, a total test measures overall

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*Note: The term "comprehension" as used in previous research relating to compressed speech should not be confused with the term identifying the Comprehension Test developed by Dwyer. The term as used by Dwyer refers specifically to the ability to "use information to explain some other phenomenon" (Dwyer, 1972), whereas the general term "comprehension" refers to a more generalized ability which could interchangeably be called learning or achievement.

achievement on all tasks. The use of such materials would seem to represent a more precise method of evaluating achievement or comprehension of information via the auditory mode.

Procedure/Method

The stimulus materials consisted of the 2,000 word instructional script on the parts and functions of the human heart developed by Dwyer (1972). A professional narrator was used to record the normal version of the audio tape at an average rate of 150 words per minute. A compressed version of 250 words per minute was provided by use of the Variable Speech Control (VSC) module.

The supplemental verbal materials consisted of the printed text of the instructional script. The supplemental visual materials consisted of the 39 illustrations identified by Dwyer as the simple line drawing version of the instructional materials on the human heart. These visuals were 35mm slides produced with black lines on a white background. The slides were synchronized to the audio script via a Wollensak 2550 cassette tape recorder at the locations in the instructional script where Dwyer determined that a visual was needed.

The accompanying four achievement tests developed by Dwyer (drawing test, terminology test, identification test and comprehension test) were employed as evaluation instruments.

The population for this study consisted of 40 graduate students at the University of Pittsburgh. Care was taken to exclude any individuals having had prior, formal training in medicine, physiology or anatomy as well as any subjects trained in Cardio-Pulmonary Resuscitation (CPR). Students also excluded from the study were those with a diagnosed hearing

loss or visual impairment as well as students who did not speak English as a first language.

Subjects were randomly assigned to one of the four treatment groups: Normal version/no augmentation, Compressed version/no augmentation, Compressed version/text augmentation, Compressed version/visual augmentation. Small groups listened to their respective versions of the script augmented by text or visuals where applicable. Upon completion of the experimental treatments the subjects were immediately administered the four achievement tests.

Findings

One way analyses of variance were calculated to determine if differences existed among the means of the four treatment groups for each of the achievement tests. Where overall F values were found to be significant, Scheffe post hoc comparisons were conducted.

The means and standard deviations for each of the four treatment groups (Normal version/no augmentation, Compressed version/no augmentation, Compressed version/printed text augmentation, and Compressed version/visual augmentation) across the five objective tests (the drawing test, the terminology test, the identification test, the comprehension test, and the total test) are presented in Table 1.

The results of the analyses of variance for each of the achievement tests are presented in Table 2.

An F value of 3.41 was obtained for the drawing test. This value was significant at the .028 level. Pairwise comparisons among means were conducted via the Scheffe test. Results of the test indicated that treatment 4, the compressed version (250 wpm) with the visual augmentation group

TABLE 1

Means and Standard Deviations of the Four Treatment Groups

	Normal/no augmentation N = 10		Compressed/no augmentation N = 10		Compressed/ printed text N = 10		Compressed/ visuals N = 10	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Drawing test	6.30	3.83	4.90	4.63	6.60	5.04	10.90	4.15
Terminology test	13.00	3.77	8.00	3.43	10.30	3.13	9.20	4.39
Identification test	11.50	5.52	8.20	3.79	9.60	2.72	11.30	4.00
Comprehension test	11.40	2.67	8.60	3.20	11.40	3.24	8.00	2.75
Total test	42.20	12.50	29.70	12.12	38.00	11.40	39.40	12.40

TABLE 2

Results of the Analyses of Variance

Test	F	p
Drawing test	3.41	.028
Terminology test	3.31	.031
Identification test	1.42	.254
Comprehension test	3.68	.020
Total test	1.97	.136

achieved significantly higher than did treatment 2, the compressed version (250 wpm) with no augmentation group. No other significant differences were found.

An F value of 3.31 was obtained for the terminology test. This value was significant at the .031 level. Comparisons among the means via the Scheffe procedure indicated that treatment 1, the normal version (150 wpm) with no augmentation achieved significantly better than treatment 2, the compressed version (250 wpm) with no augmentation.

An F value of 1.42 was obtained for the identification test. This value was not significant ($p = .254$).

An F value of 3.68 was obtained for the comprehension test. This value was significant at the $p = .020$ level. However, pairwise comparisons via the Scheffe procedure indicated no significant differences.

An F value of 1.97 was obtained for the total test. This value was not significant ($p = .136$).

Conclusions and Discussion

A number of conclusions can be drawn from the analyses obtained in this study.

With regard to a spatial restructuring task as measured by the drawing test:

1. Visual augmentation to compressed speech is more effective than compressed messages presented without augmentation. It is clear that a task such as this relies heavily upon spatial information. Such information is provided by the visual material used to augment the compressed recording.

2. The data further suggest that in those cases where no visual augmentation is provided, both compressed and normal messages are equally effective. Such a conclusion would lend support to the use of compressed messages regardless of augmentation in those cases where instructional efficiency in terms of time is desirable.

With regard to the recall of specific information as measured by the terminology test:

1. The evidence suggests that normal presentation rates are superior to compressed rates when information is technical in nature.

2. In those cases where compressed presentation rates are used, augmentation of any type does not appear to be a significant factor.

With regard to spatial analysis tasks as measured by the identification test:

1. The data suggest that compressed messages do not differ from normal messages in terms of their instructional effectiveness. For this reason, rate-modified messages may be considered instructionally more efficient in terms of time with no loss of effectiveness.

With regard to the interrelationship of information as measured by

the comprehension test:

1. Evidence indicates that for a task of this nature compressed messages do not appear to differ significantly in their instructional effectiveness from those presented at a normal rate of speed.

It is of importance to note that although a significant F value was obtained, no significant pairwise comparisons could be identified. Such a finding would make the above conclusion tentative and may suggest a need for further research.

With regard to overall understanding of technical information as measured by the total test:

1. The data suggest that no reason exists to believe that compressed messages differ in instructional effectiveness from normal rate messages when the information presented is technical in nature.

2. The data further indicate that compressed and normal speed materials are not equally effective in facilitating student achievement of different instructional objectives. The rate of presentation most effective in presenting information is dependent upon the type of learning task.

3. The effectiveness of a particular type of augmentation to a compressed passage is dependent upon the required instructional task.

The fact that various types of augmentation to compressed materials represent varying degrees of information, redundancy should be further explored.

4. The degree of information redundancy provided by varying types of augmentation techniques does not appear to be related to the overall instructional effectiveness of the message. Although the overall degree of redundancy differed from 100% in the text augmentation version to slight redundancy in the visual (labels of terms on diagrams), the effectiveness

of those techniques appears to be more directly related to the type of information useful in completing the learning task.

The findings of this study strongly suggest that further research be conducted to confirm or disconfirm the hypothesis that verbal and visual augmentation of rate-modified speech is an effective supplement in the learning of technical information. Research should focus on more specifically analyzing the stimulus passages utilized with regard to their complexity, readability, density of ideas and length. Further research should also address the use of augmentation which varies in its degree of visual complexity and redundancy.

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